Russian-American Long-Term Census of the Arctic Cruise Principal Investigator Meeting

Hotel Splendido, Prcanj Montenegro

25-28 November 2005

Benthic sampling results

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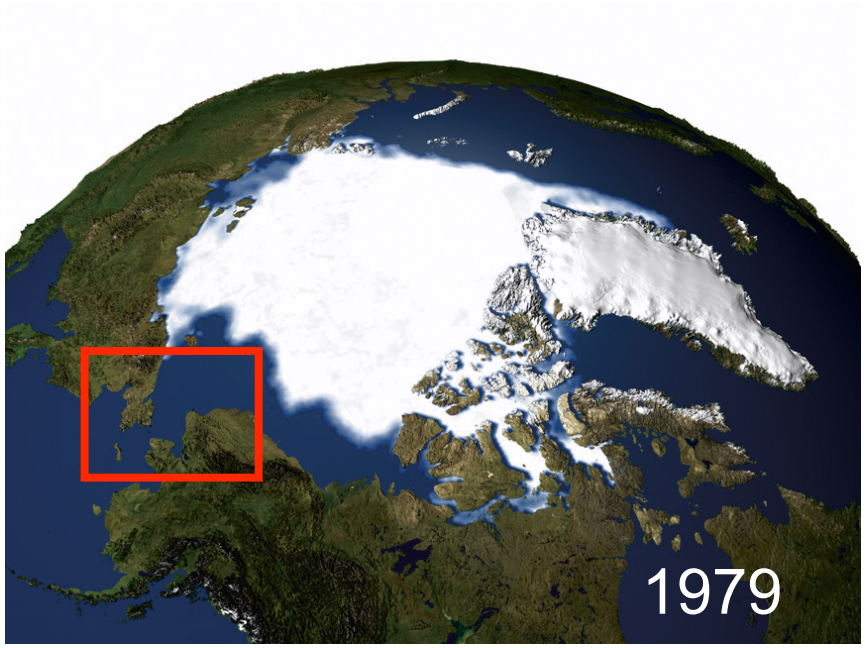
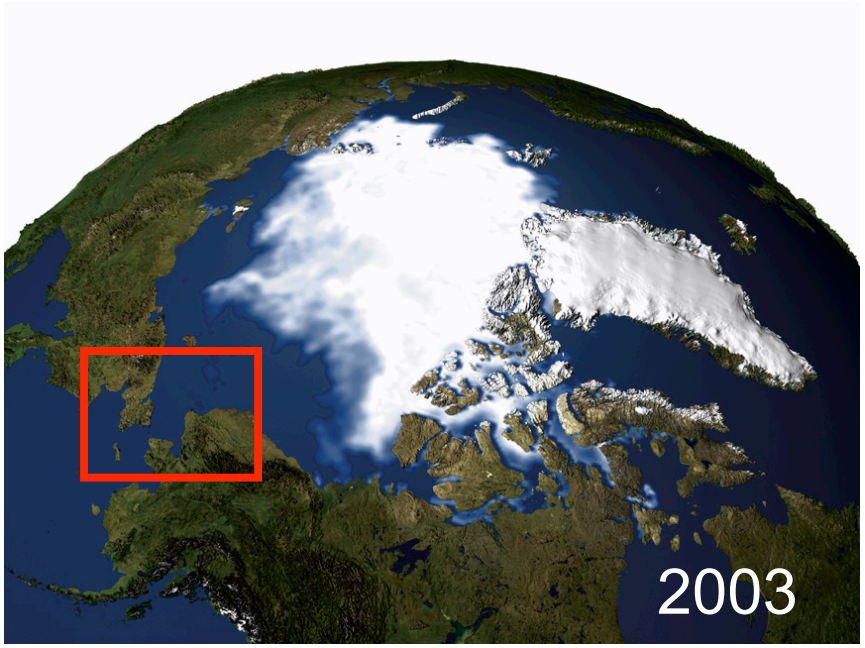
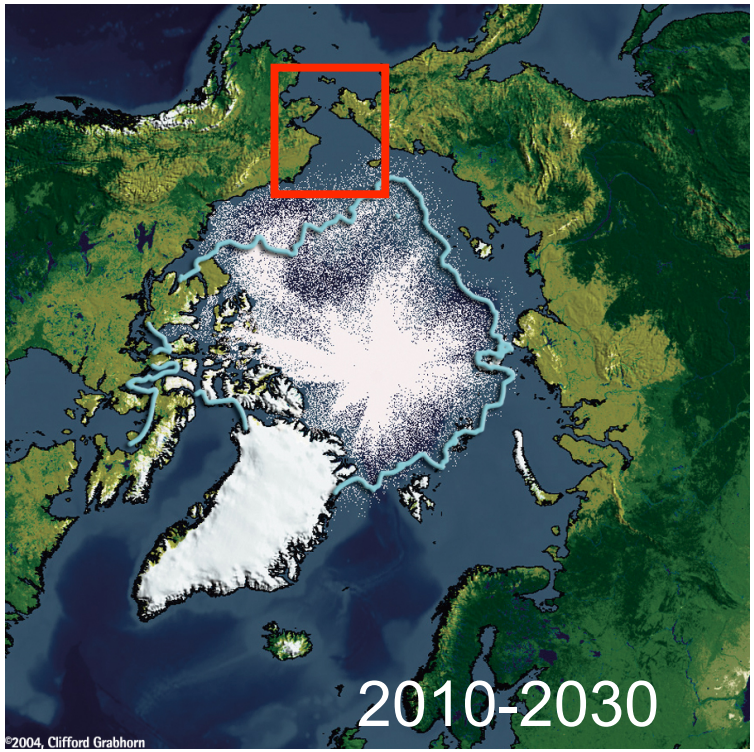
Importance of Benthic Sampling on the Chukchi Shelf

- High productivity over wide shallow shelves leads to high benthic biomass
- Benthic populations support large populations of diving ducks, walruses, bearded seals and gray whales
- Subsistence harvesting of these animals locally important for human consumption
- Vulnerability to environmental change is high

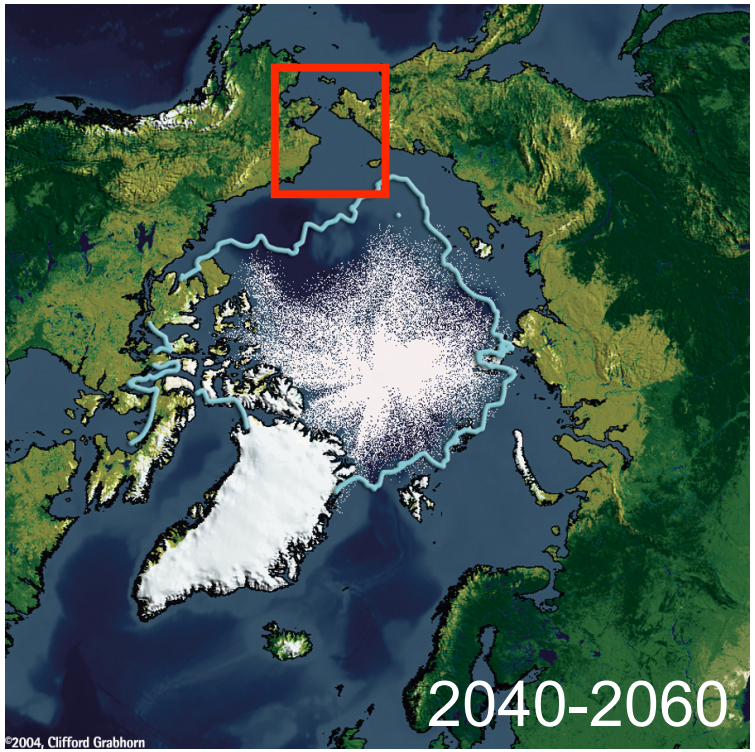
Photo credit: Kathy Crane

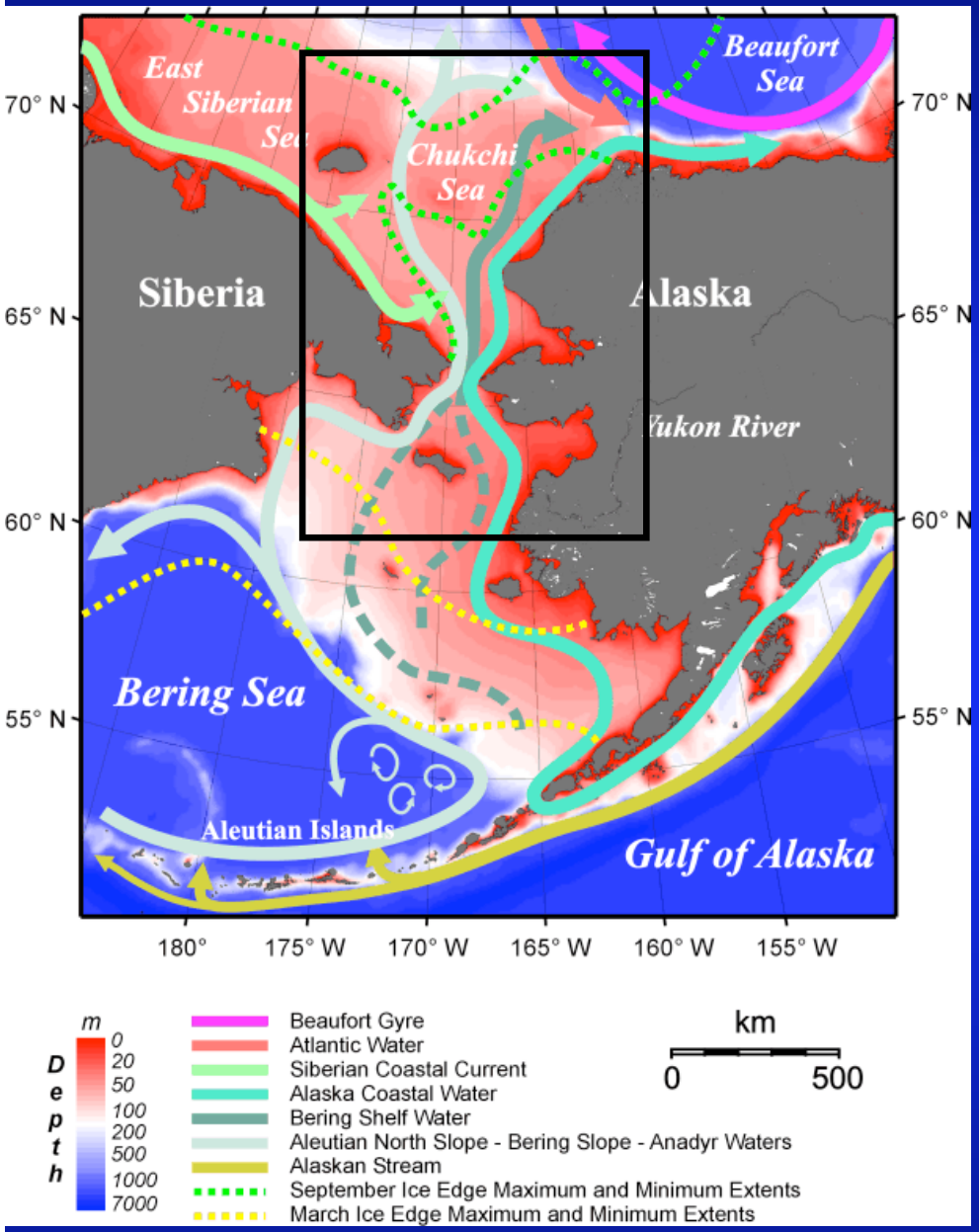






Sea ice extent in the Arctic- past, current, and future

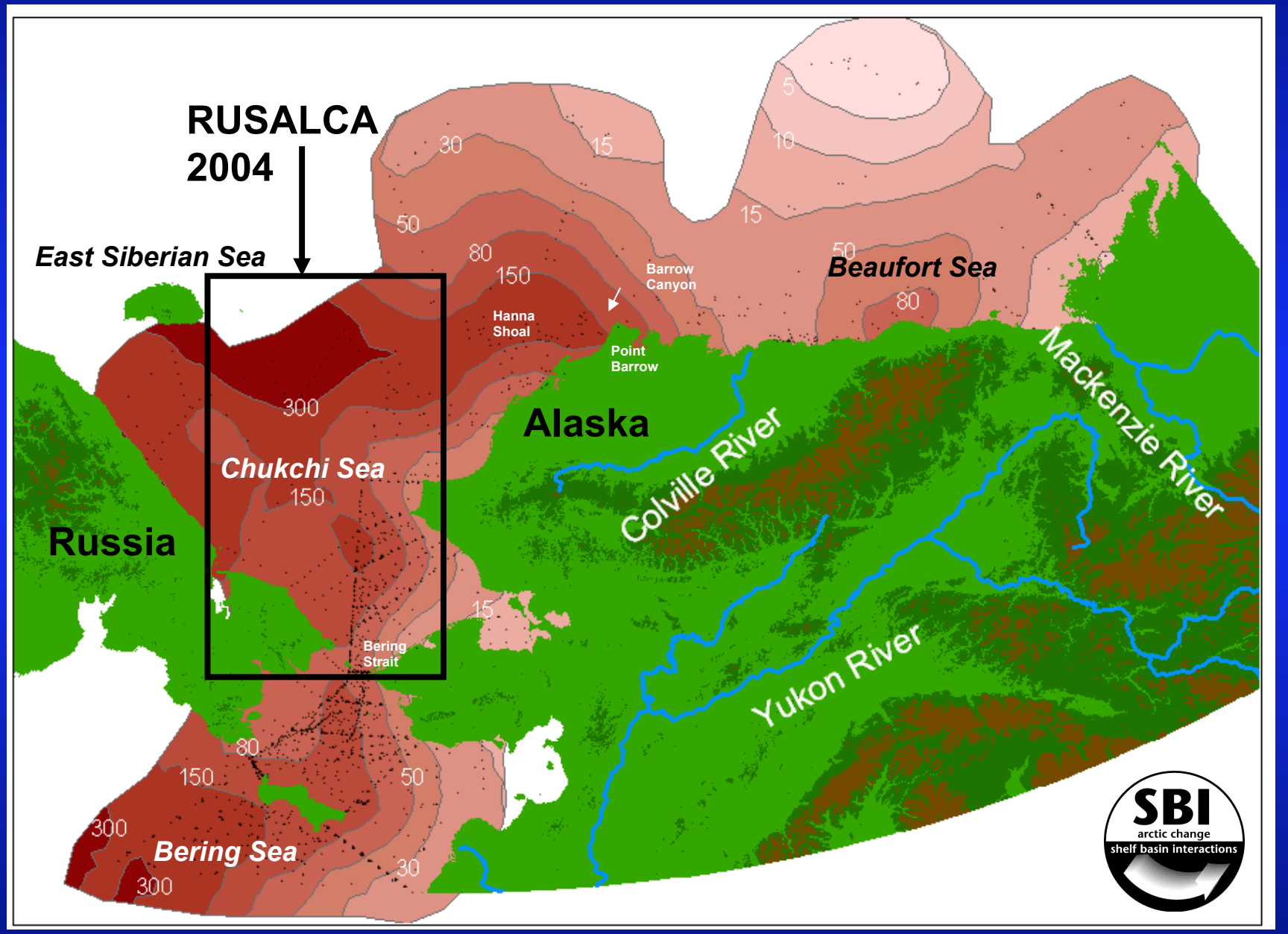




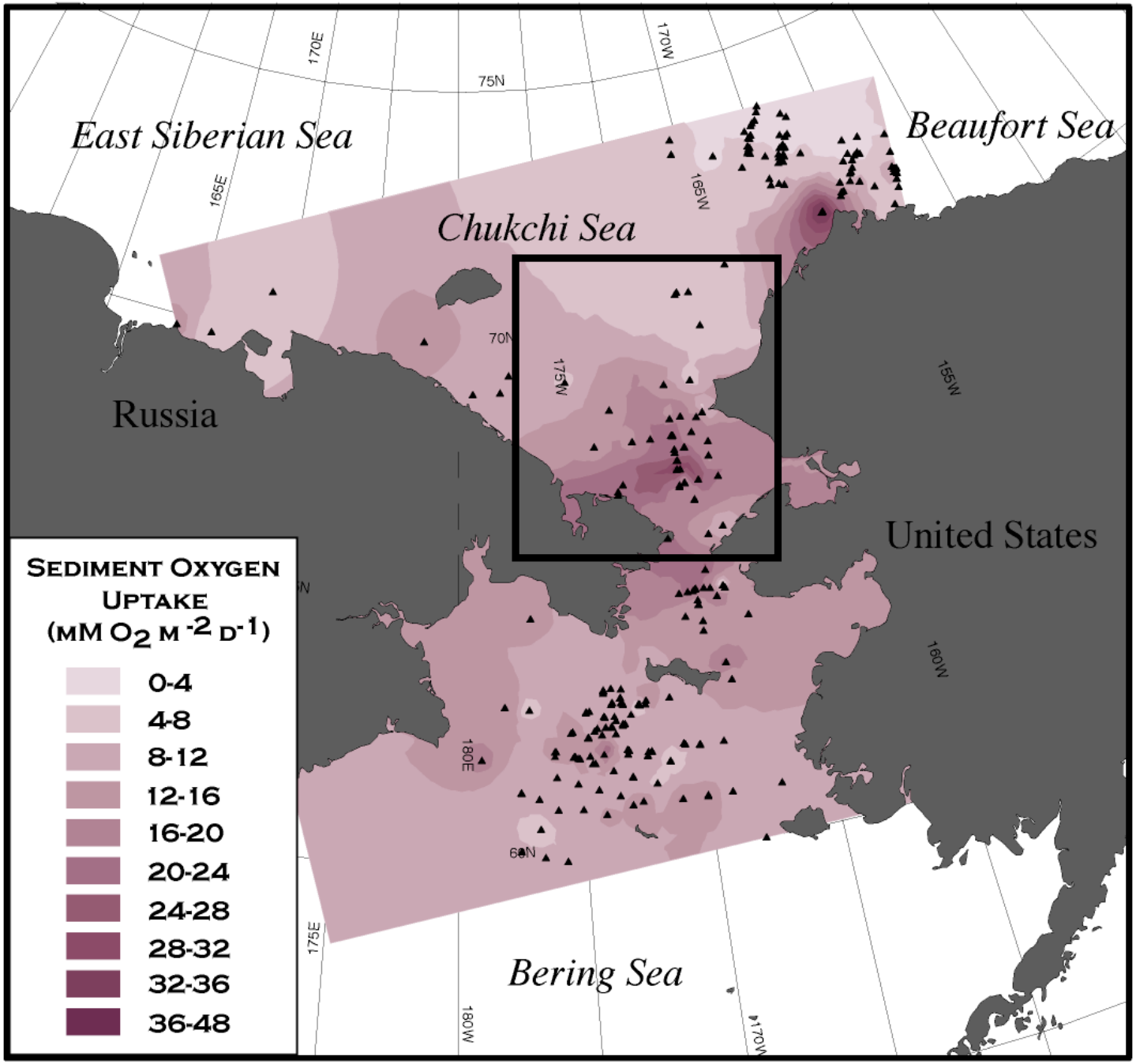
[courtesy Tom Weingartner]

- high-latitude Arctic shelf system highly productive under Pacific water influence
- sea ice important, influences seawater temperature
- timing annual production critical for water column production, carbon cycling, and pelagic-benthic coupling
- short food chains, thus changes in lower trophic levels can cascade efficiently to higher trophic organisms
- potential impacts of change have broad-reaching implications for long-term ecosystem structure

Integrated chlorophyll (mg m^{-2}) compiled over the period 1975-1996 (primarily open water season)



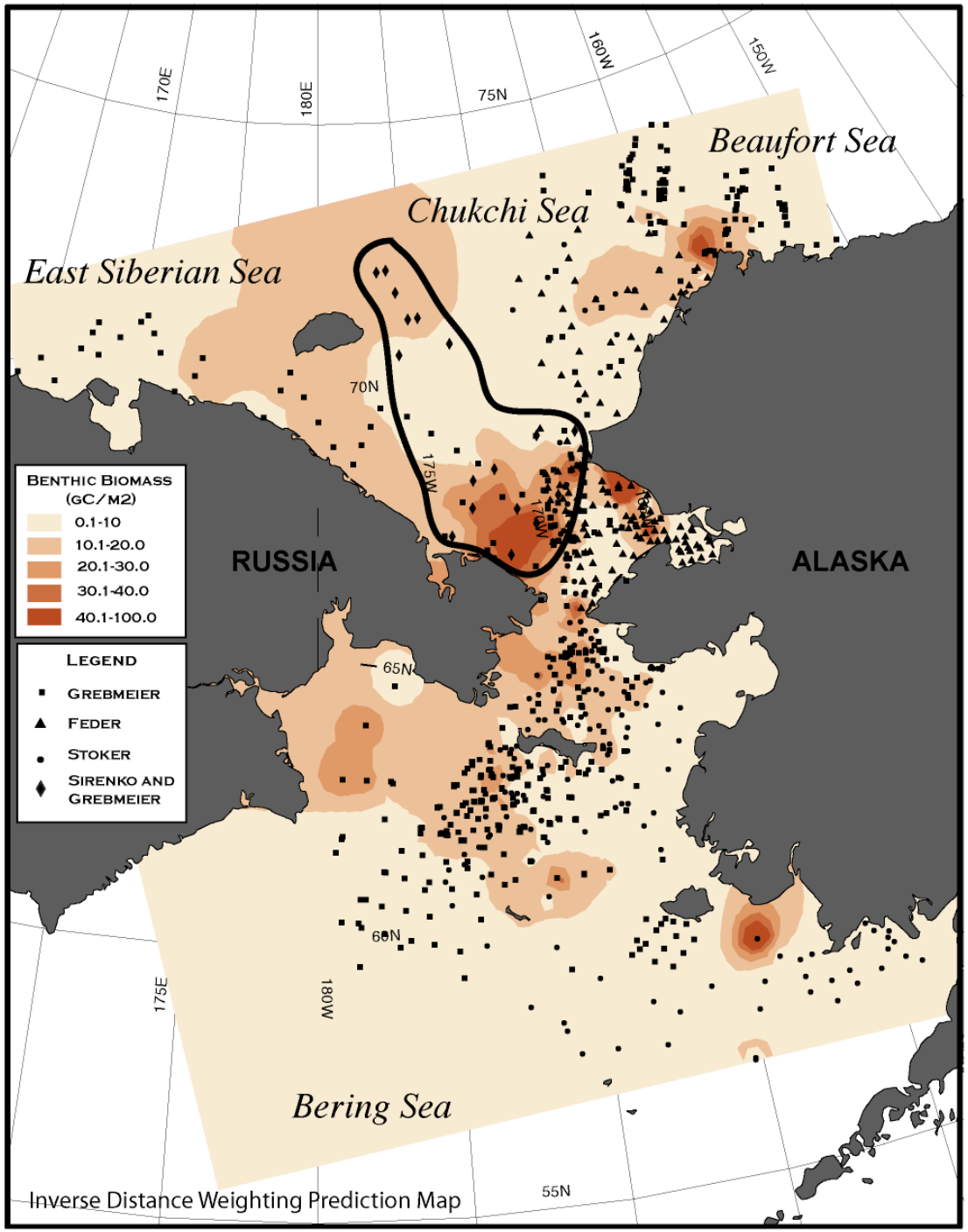
[Dunton et al., 2005, DSR in press]



[Grebmeier et al. in prep.]

Sediment community oxygen consumption (mM O_2 m^{-2} d^{-1}) from 1984-2004

- an indicator of carbon supply to the underlying benthos
- persistent patterns of carbon flux to sediments
- highest SCOC in RUSALCA study area in southern Chukchi Sea



Macroinfaunal biomass (g C m^{-2}) from 1977-2004

- wet weight biomass converted to carbon biomass
- allows removal of heavy carbonate test value
- identified “foot prints” of high carbon deposition and benthic biomass on the shallow continental shelves for time series investigations embedded in periodic process studies
- black outlined region encompasses 2004 RUSALCA benthic stations

[Grebmeier et al. in prep.]

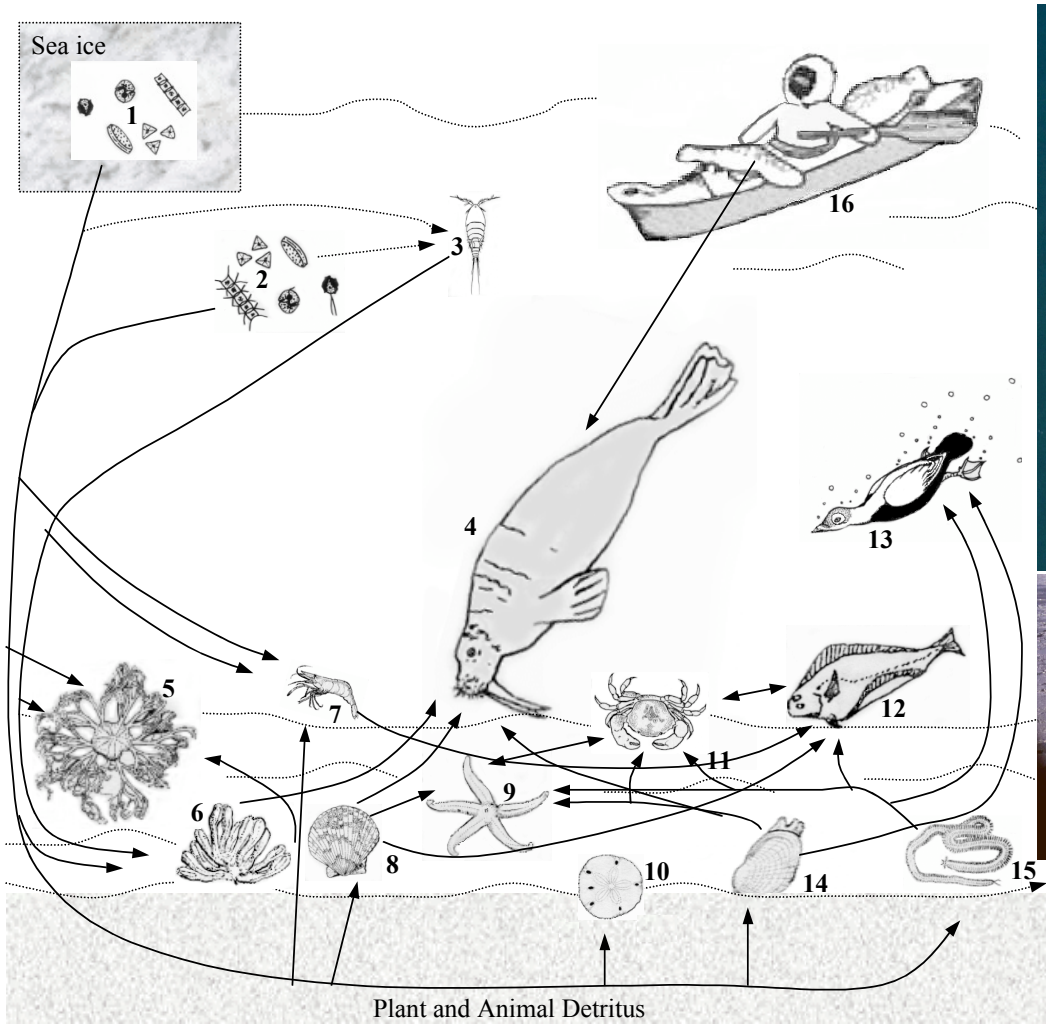


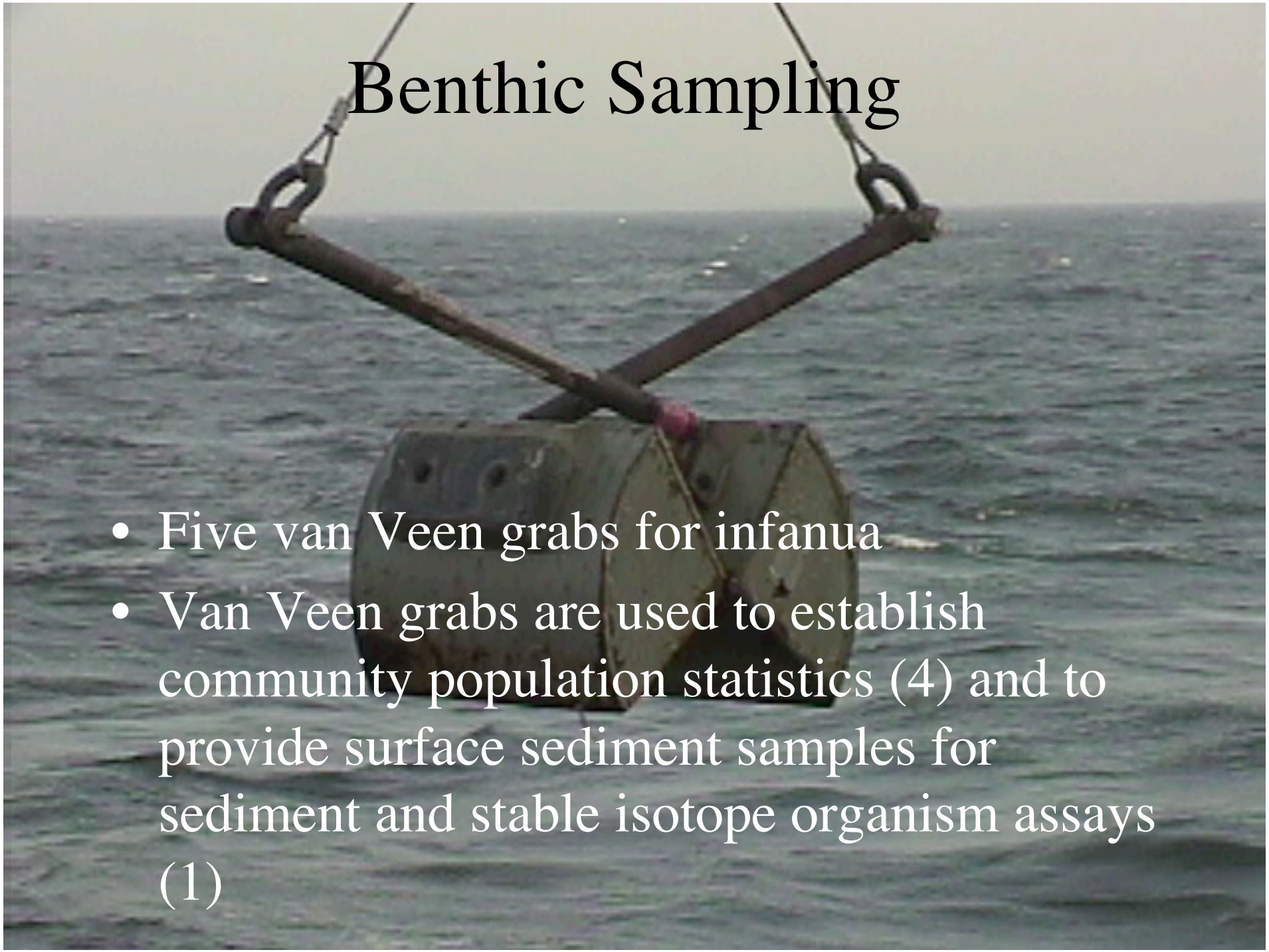
Figure 3. Representation of a simplified northern Bering/Chukchi Sea food web. The high density and abundance of benthic biota reflects the large proportion of phytoplankton that falls directly to the seabed, ungrazed by pelagic organisms. The direct assimilation of phytoplankton by the benthos results in shorter food chains and a more efficient transfer of carbon to large marine mammals and diving seabirds.

Organisms are: 1: ice algae; 2: phytoplankton; 3: copepods; 4: walrus; 5: basket stars; 6: ascidians; 7: shrimps; 8: filter-feeding bivalves; 9: sea stars; 10: sand dollars; 11: crabs; 12: bottom feeding fishes; 13: diving seabirds; 14: deposit feeding bivalves; 15: polychaetes, 16: native subsistence hunters.

Cascading potential high from lower to higher trophic levels

[Grebmeier and Dunton 2000]

Benthic Sampling



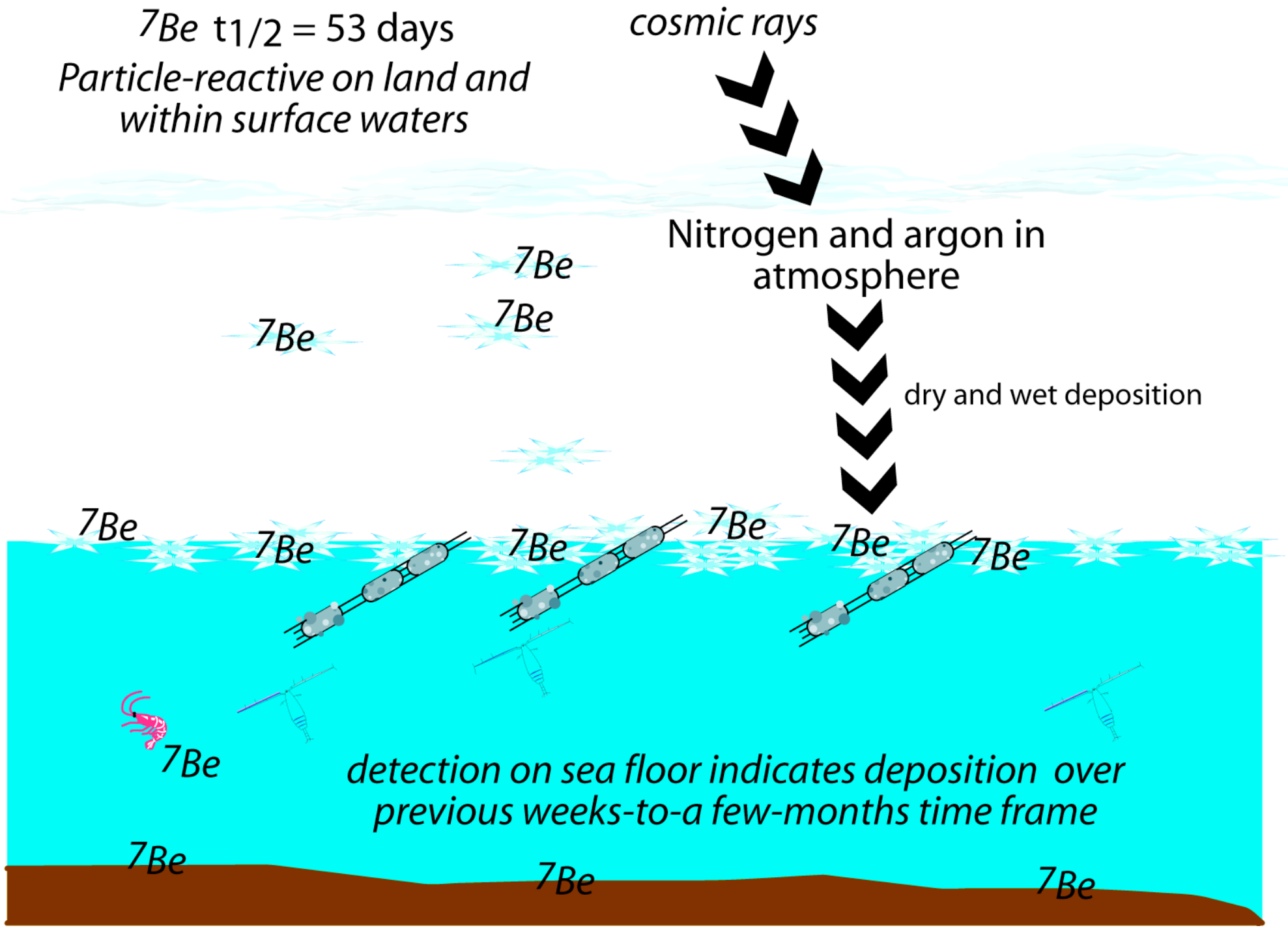
- Five van Veen grabs for infanua
- Van Veen grabs are used to establish community population statistics (4) and to provide surface sediment samples for sediment and stable isotope organism assays (1)

Laboratory Efforts on Infaunal Communities

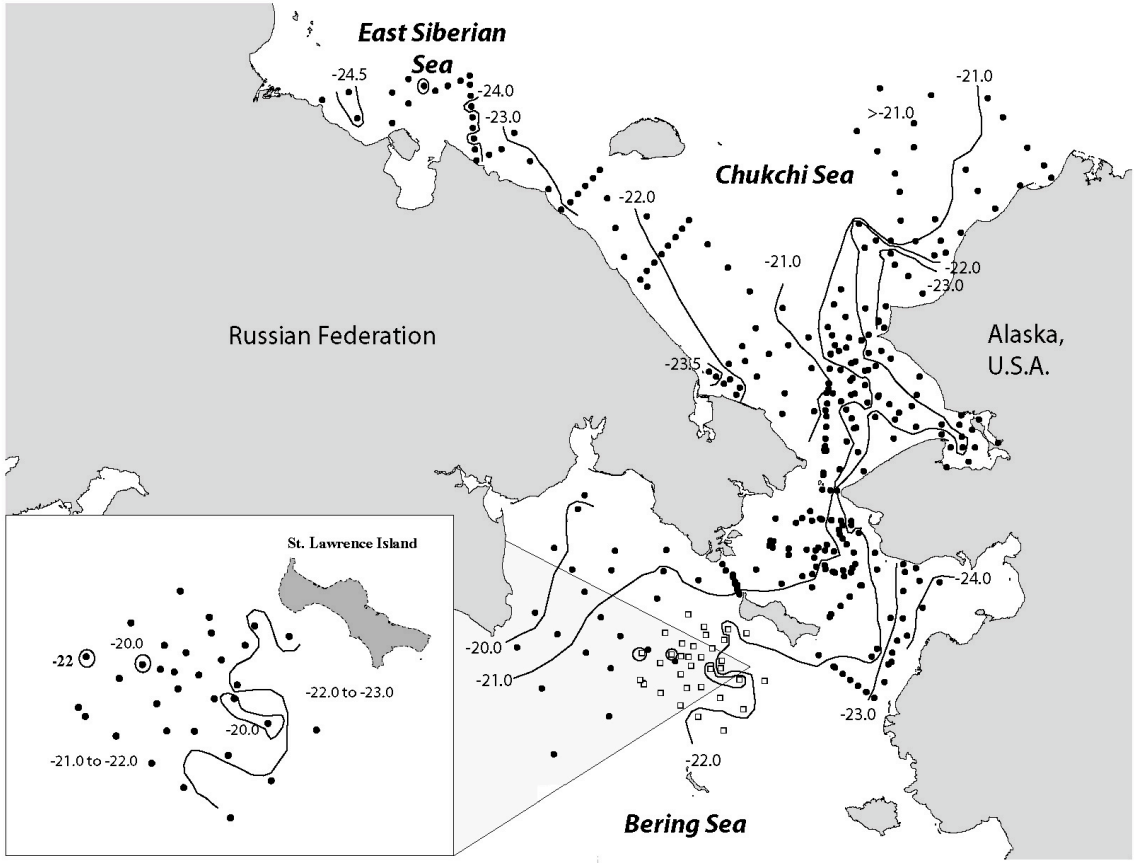
- Coordination and cooperation with other funded research groups
- Species identification and sorting underway from February - July 2005
- Biomass determinations (per square meter)
- Statistical analyses of benthic community composition and structure
- Approximately 1000 hours of laboratory effort
  - Two upper division undergraduates and one graduate student
  - Research Specialist Dr. Becky Brown

Surface sediment parameters to be sampled (surface sediments)

- Stable carbon isotope ratios of sediment organic matter
- C/N ratios
- Gamma-emitting radionuclides
- Grain size


7Be t1/2 = 53 days
Particle-reactive on land and within surface waters
cosmic rays
Nitrogen and argon in atmosphere
dry and wet deposition
7Be
detection on sea floor indicates deposition over previous weeks-to-a few-months time frame

Carbon isotope composition of organic carbon in surface sediments



From Cooper et al. 2002, Marine Ecology Progress Series 226:13-26

Areas of Interest

- North of central Chukotka (High benthic biomass)
- Gulf of Anadyr (high productivity water)
- Bering Strait (Combined U.S. and Russian sectors; water column sampling only because of hard bottom)
- Herald Canyon and near Wrangel Island

Coordination With Other Programs

- Shelf-Basin Interactions

$^{18}O/^{16}O$ ratios as a water mass tracer

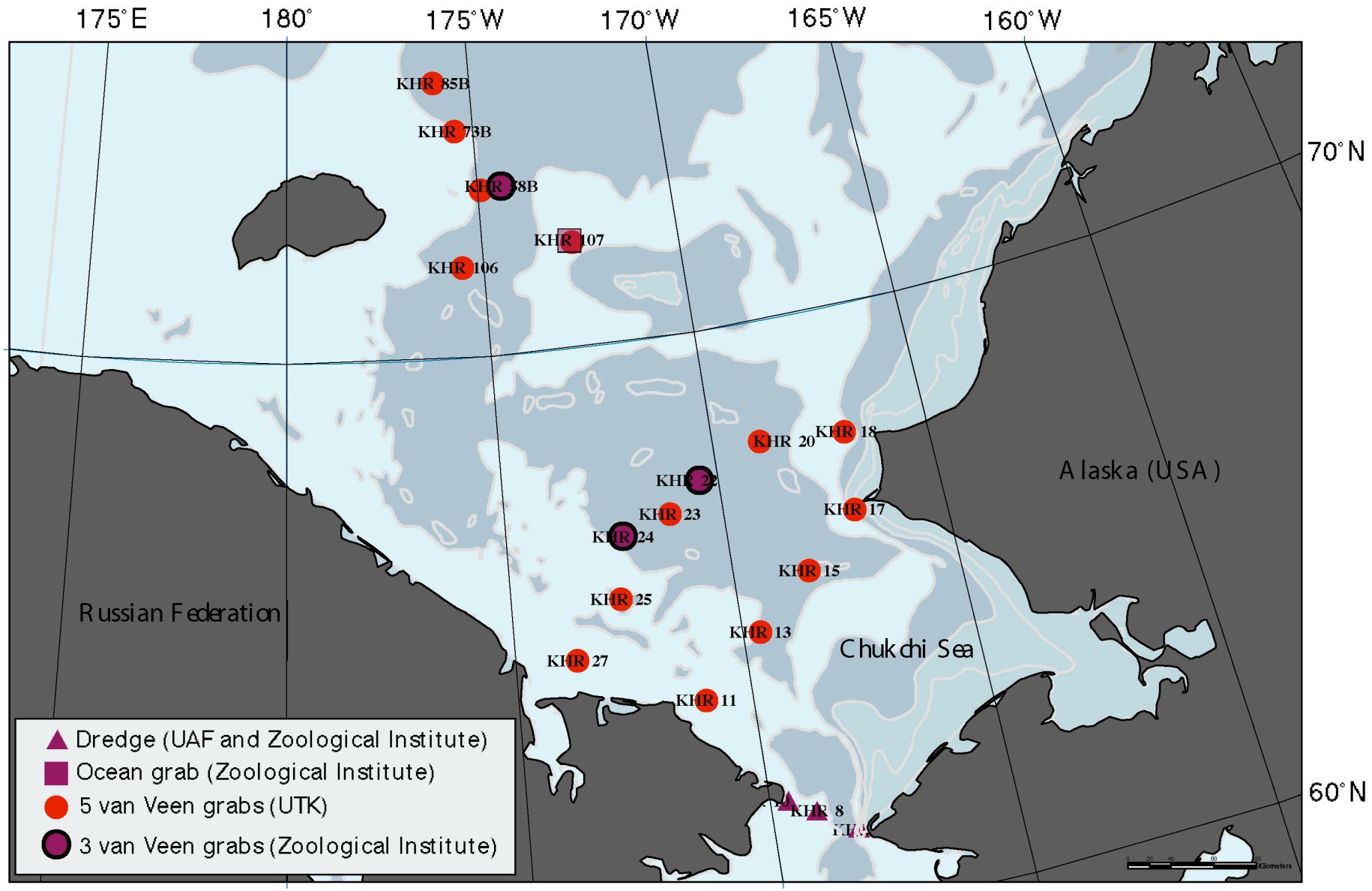
Radionuclides in sea ice and sediments, including ^{7}Be and ^{137}Cs

- Bering Strait Environmental Observatory

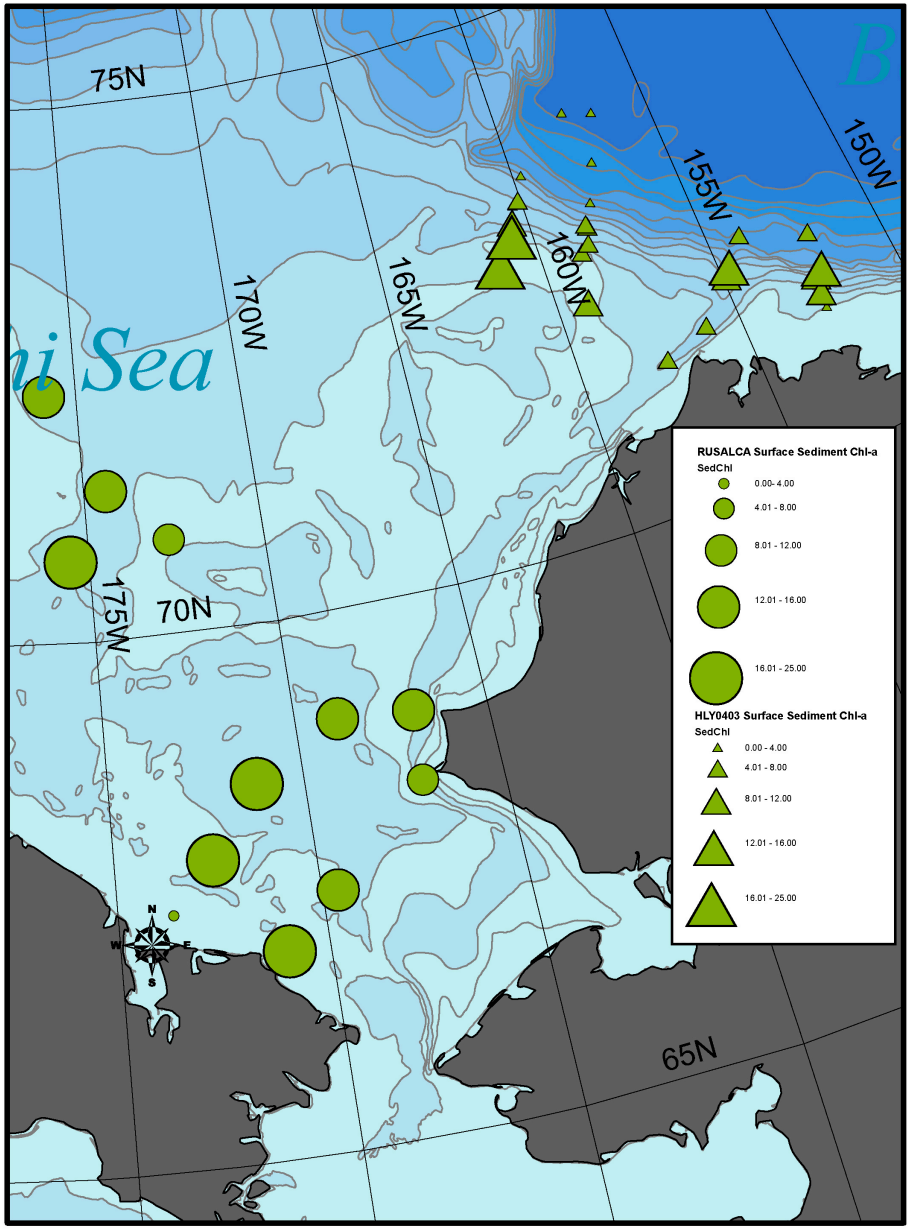
Benthic “hot-spot” sampling north and south of Bering Strait

$^{18}O/^{16}O$ ratios as a water mass tracer

Supported by NSF and NOAA

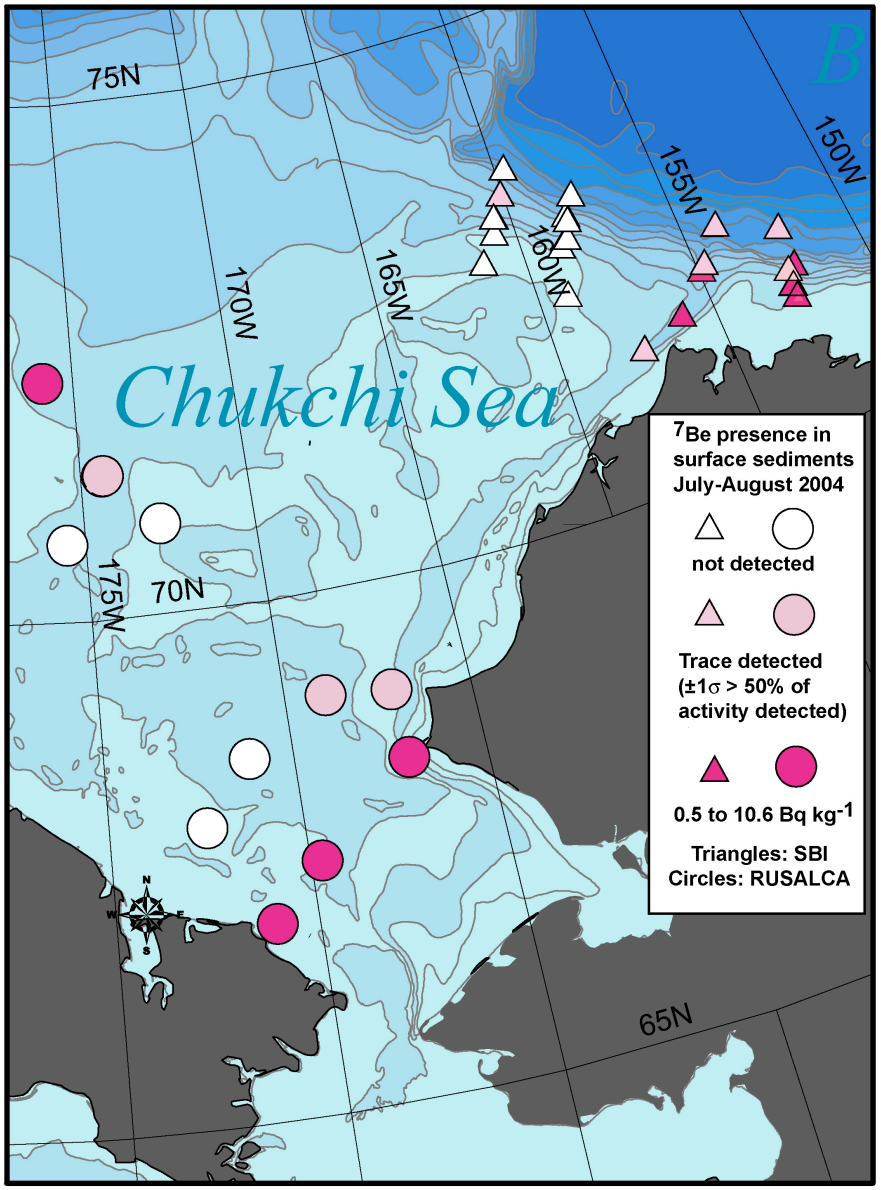

175°E
180°
175°W
170°W
165°W
160°W
70°N
60°N
KHR 85B
KHR 73B
KHR 78B
KHR 107
KHR 106
KHR 20
KHR 18
KHR 22
KHR 23
KHR 17
KHR 24
KHR 15
KHR 25
KHR 13
KHR 27
KHR 11
KHR 8
Alaska (USA)
Russian Federation
Chukchi Sea
Dredge (UAF and Zoological Institute)
Ocean grab (Zoological Institute)
5 van Veen grabs (UTK)
3 van Veen grabs (Zoological Institute)
Kilometers

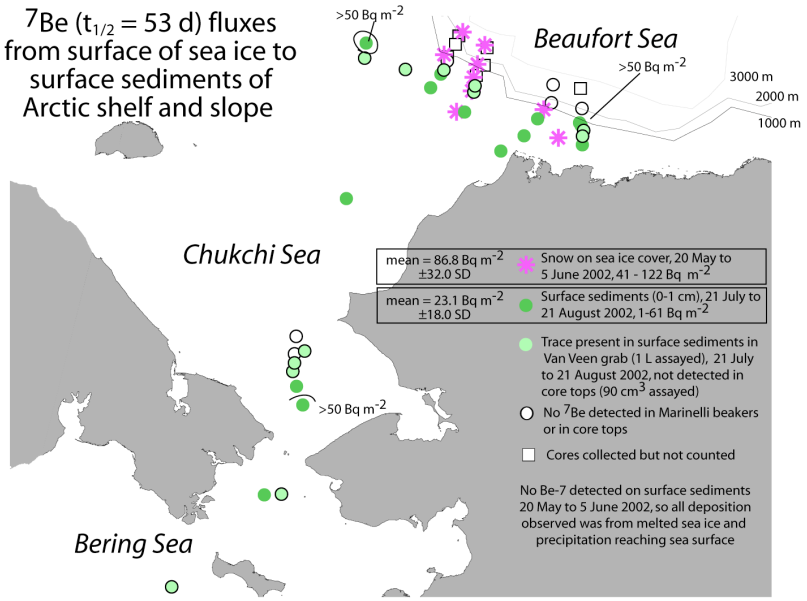
HLY0403 & RUSALCA: Surface Sediment chl-a



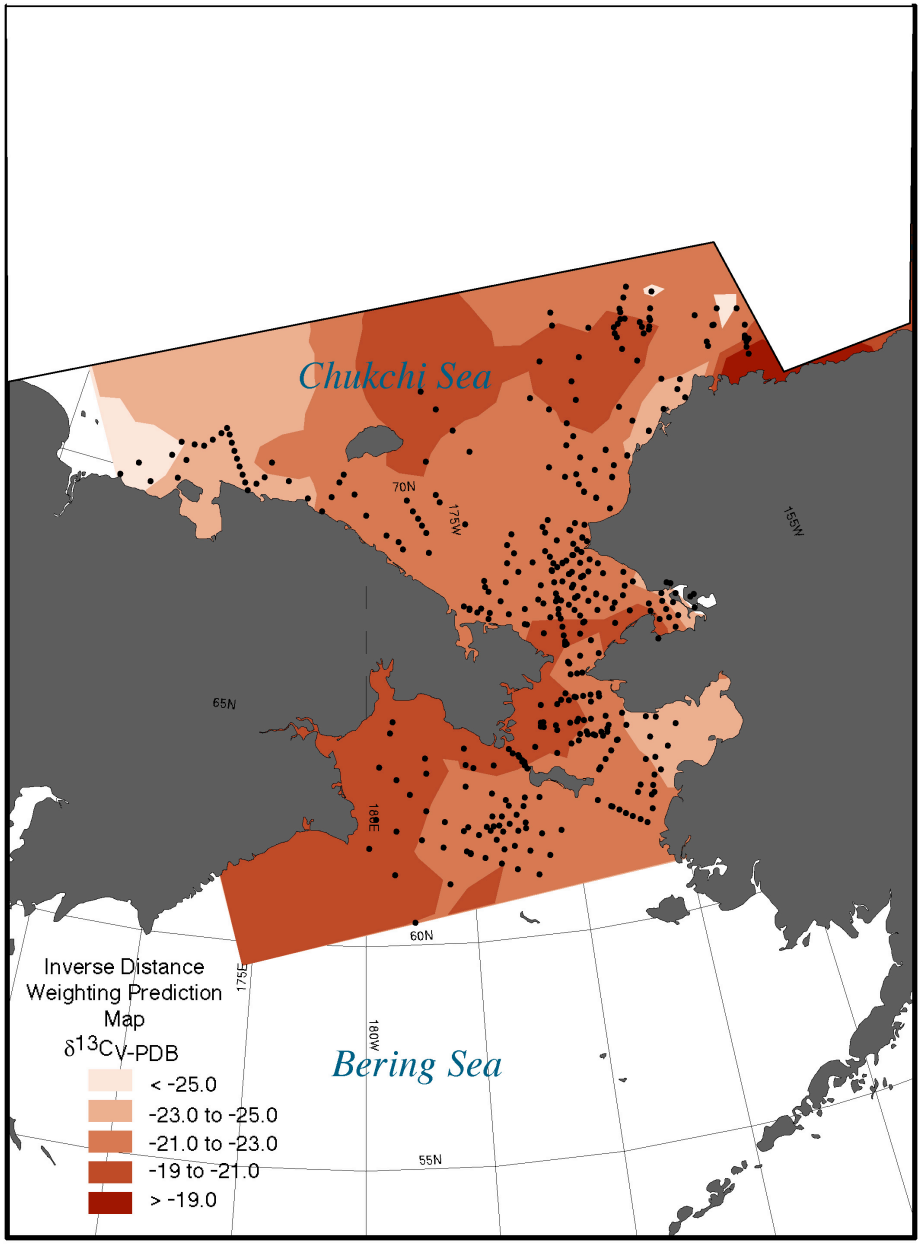
Surface sediment chlorophyll (mg chl *a* m^{-2}) data from 2004. SBI data courtesy of Rebecca Pirtle-Levy et al., University of Tennessee

HLY0403 & RUSALCA: Surface Sediment ^{7}Be

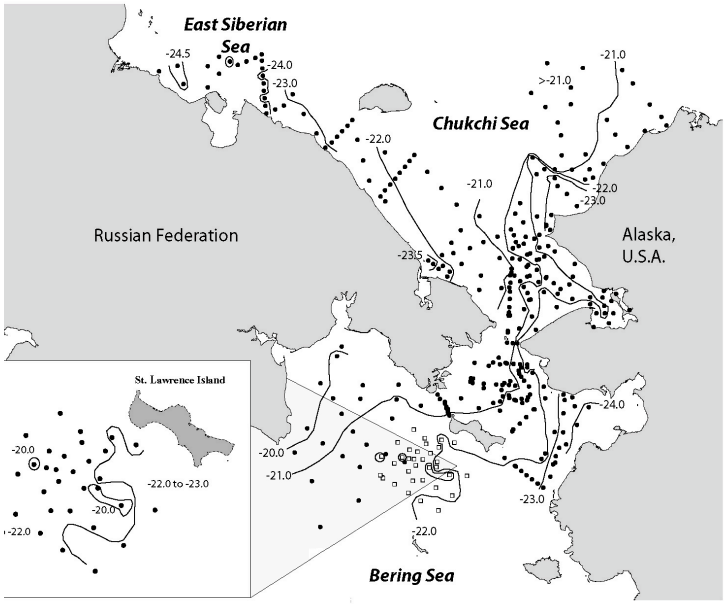




Above: SBI/BSEO data from 2002; Cooper et al. in-press, Deep-Sea Research II, December 2005 (SBI special issue)



Geographical Information System graphics by Rebecca Pirtle-Levy, UT Knoxville (in Grebmeier et al. in prep.)



$$\delta^{13}C = [(^{13}C/^{12}C_{sample})/(^{13}C/^{12}C_{standard}) - 1] \times 1000$$

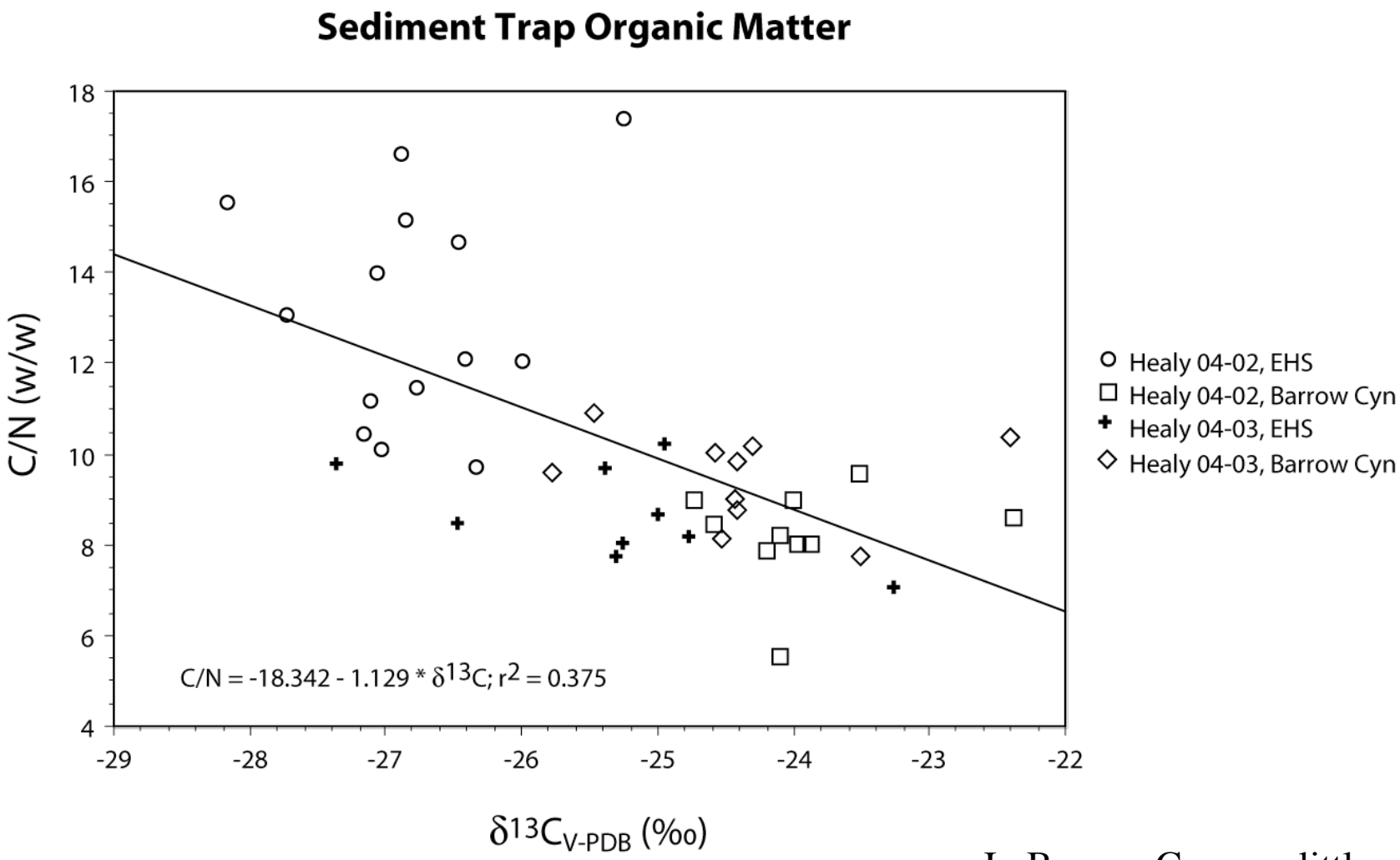
Less negative $\delta^{13}C$ values:

More marine vs. terrestrial carbon

More in-sediment processing following deposition

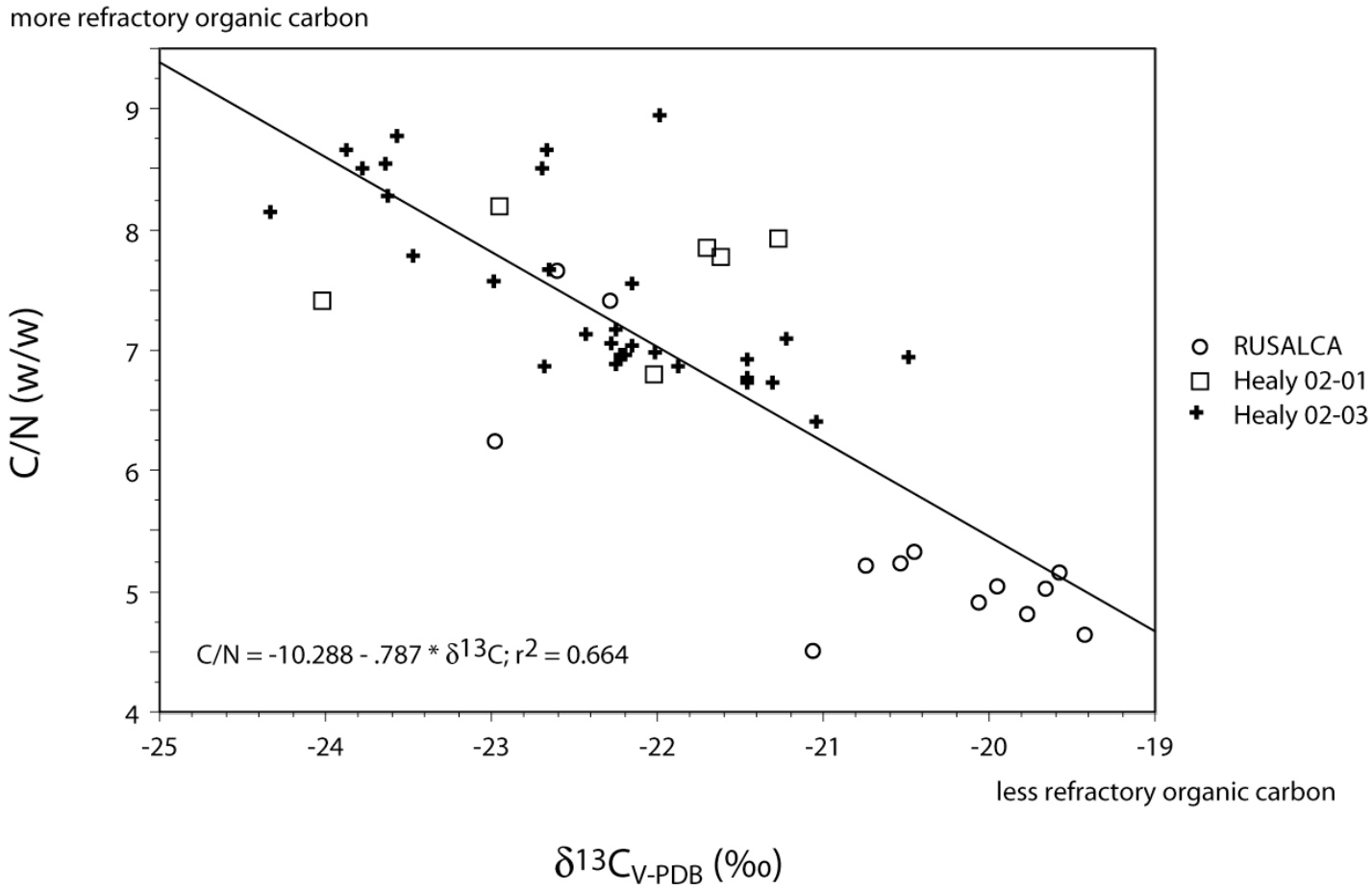
More sea algal production vs. pelagic algal production

More productive conditions (less isotopic discrimination during photosynthesis)

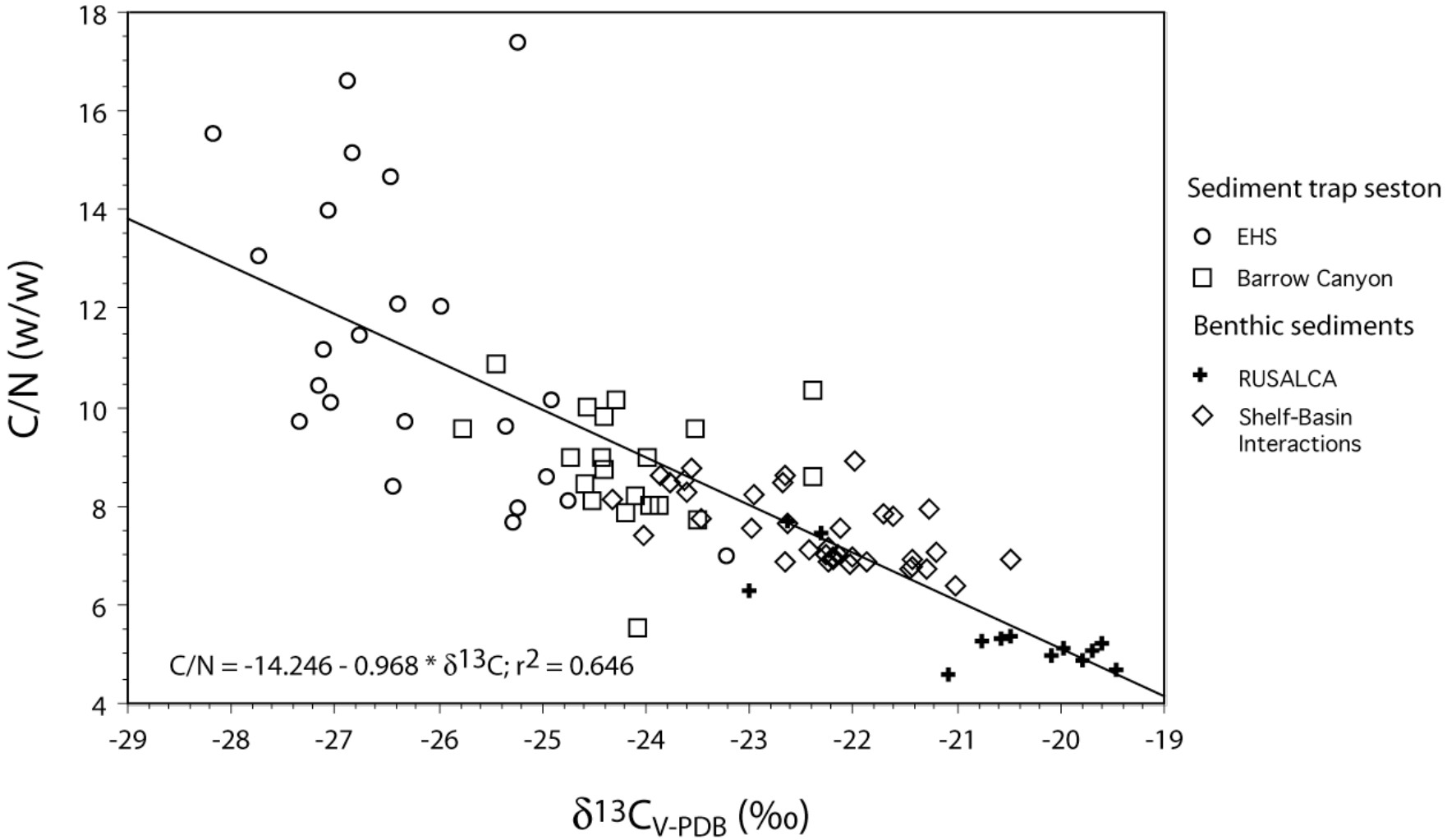


Data from Catherine Lalande et al. University of Tennessee

In Barrow Canyon, little difference in seston seasonally (ice algae unimportant?)



No obvious seasonal differences (SBI cruises); higher quality, less refractory carbon collected at many RUSALCA stations


C/N (w/w)
18
16
14
12
10
8
6
4
-29
-28
-27
-26
-25
-24
-23
-22
-21
-20
-19
δ13CV-PDB (‰)
C/N = -14.246 - 0.968 * δ13C; r2 = 0.646
Sediment trap seston
EHS
Barrow Canyon
Benthic sediments
RUSALCA
Shelf-Basin Interactions

$$\delta^{18}O_{V\text{-}SMOW} = [(^{18}O/^{16}O_{sample} \div {}^{18}O/^{16}O_{V\text{-}Standard\ Mean\ Ocean\ Water}) - 1] \times 1000$$

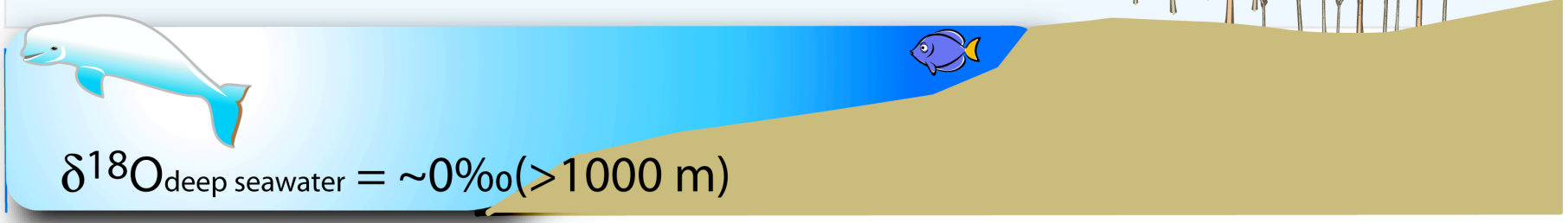
$\delta^{18}O_{tropical\ to\ temperate\ precipitation}$
$= \sim -2$ to $-15‰$

$\delta^{18}O_{arctic\ basin\ precipitation}$
$= \sim -10$ to $-35‰$

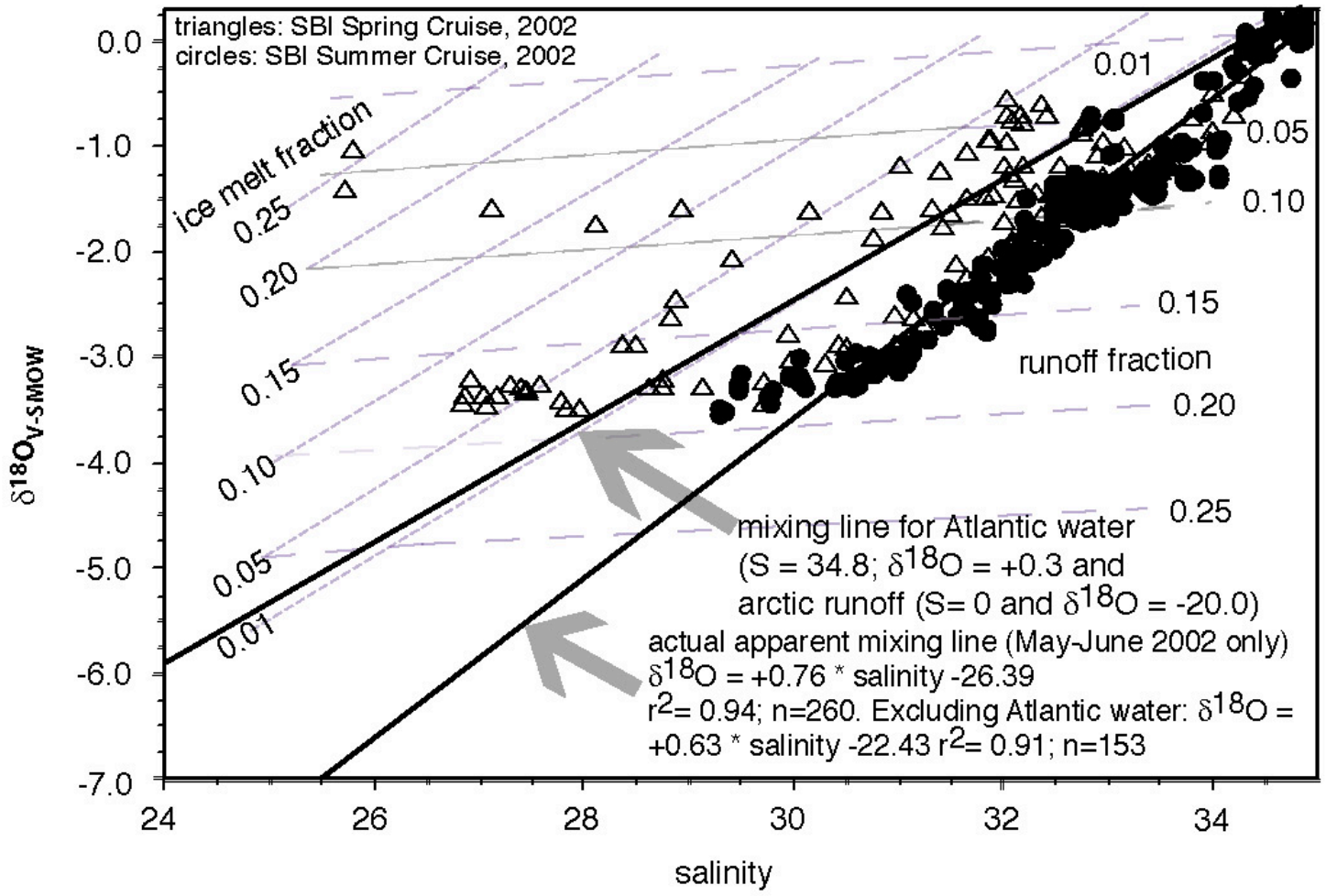
primary isotopic fractionation drivers:
season/altitude/latitude/air mass origin

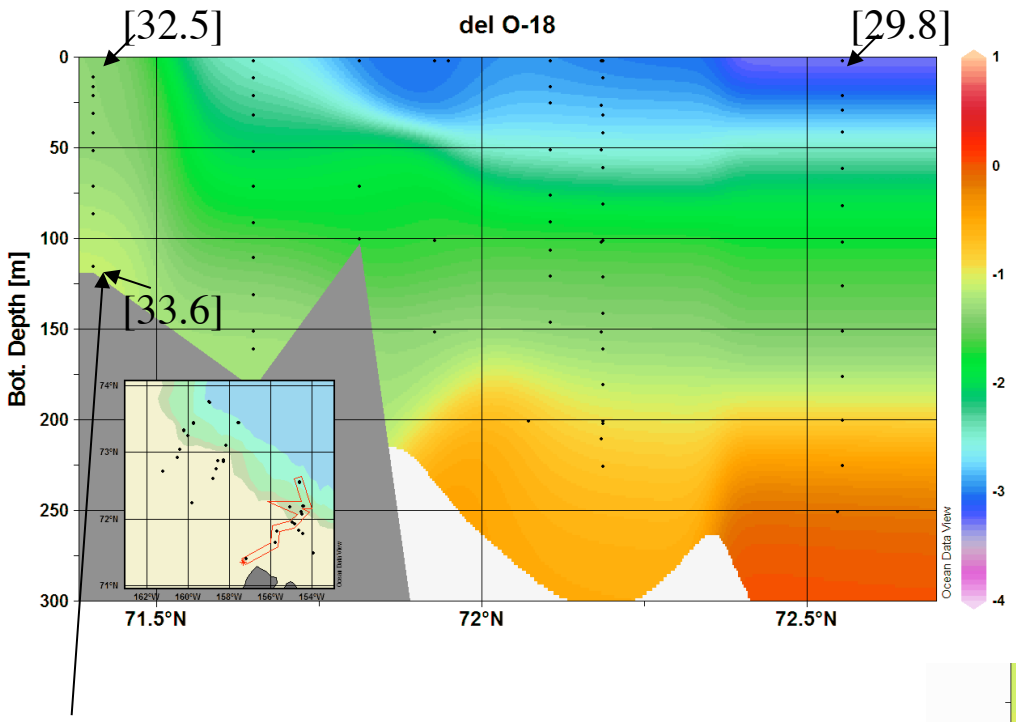
$\delta^{18}O_{leaf\ water} = \sim +3$ to $+20‰$
(above ambient source)

$\delta^{18}O_{arctic\ basin\ runoff} = \sim -21‰$
$\delta^{18}O_{sea\ ice} = \sim +2‰$



$\delta^{18}O_{deep\ seawater} = \sim 0‰ (>1000\ m)$


triangles: SBI Spring Cruise, 2002
circles: SBI Summer Cruise, 2002
ice melt fraction
0.25
0.20
0.15
0.10
0.05
0.01
runoff fraction
0.01
0.05
0.10
0.15
0.20
0.25
mixing line for Atlantic water
(S = 34.8; δ18O = +0.3 and
arctic runoff (S= 0 and δ18O = -20.0)
actual apparent mixing line (May-June 2002 only)
δ18O = +0.76 * salinity -26.39
r2= 0.94; n=260. Excluding Atlantic water: δ18O =
+0.63 * salinity -22.43 r2= 0.91; n=153
δ18OV-SMOW
salinity
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
24
26
28
30
32
34



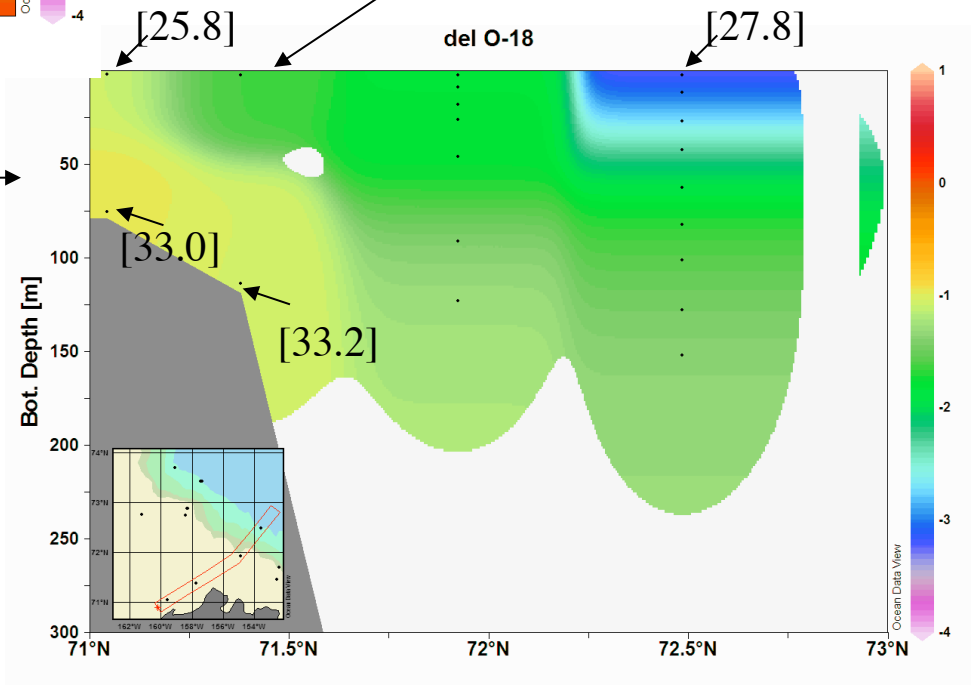
River runoff held offshore over deep water

← May-June 2002

[Salinity]

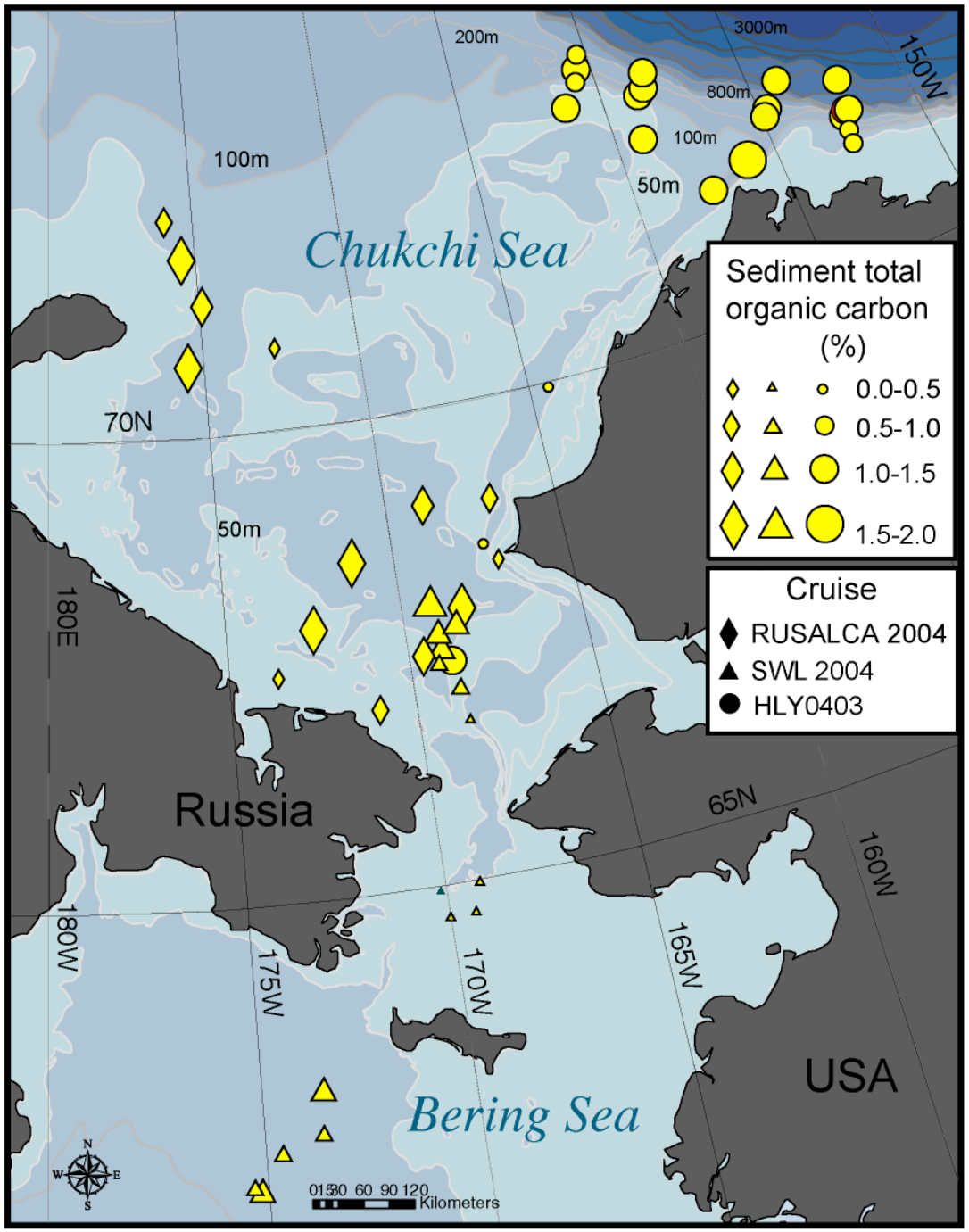
Sea ice melt on inshore surface

Brine-injected shelf water →



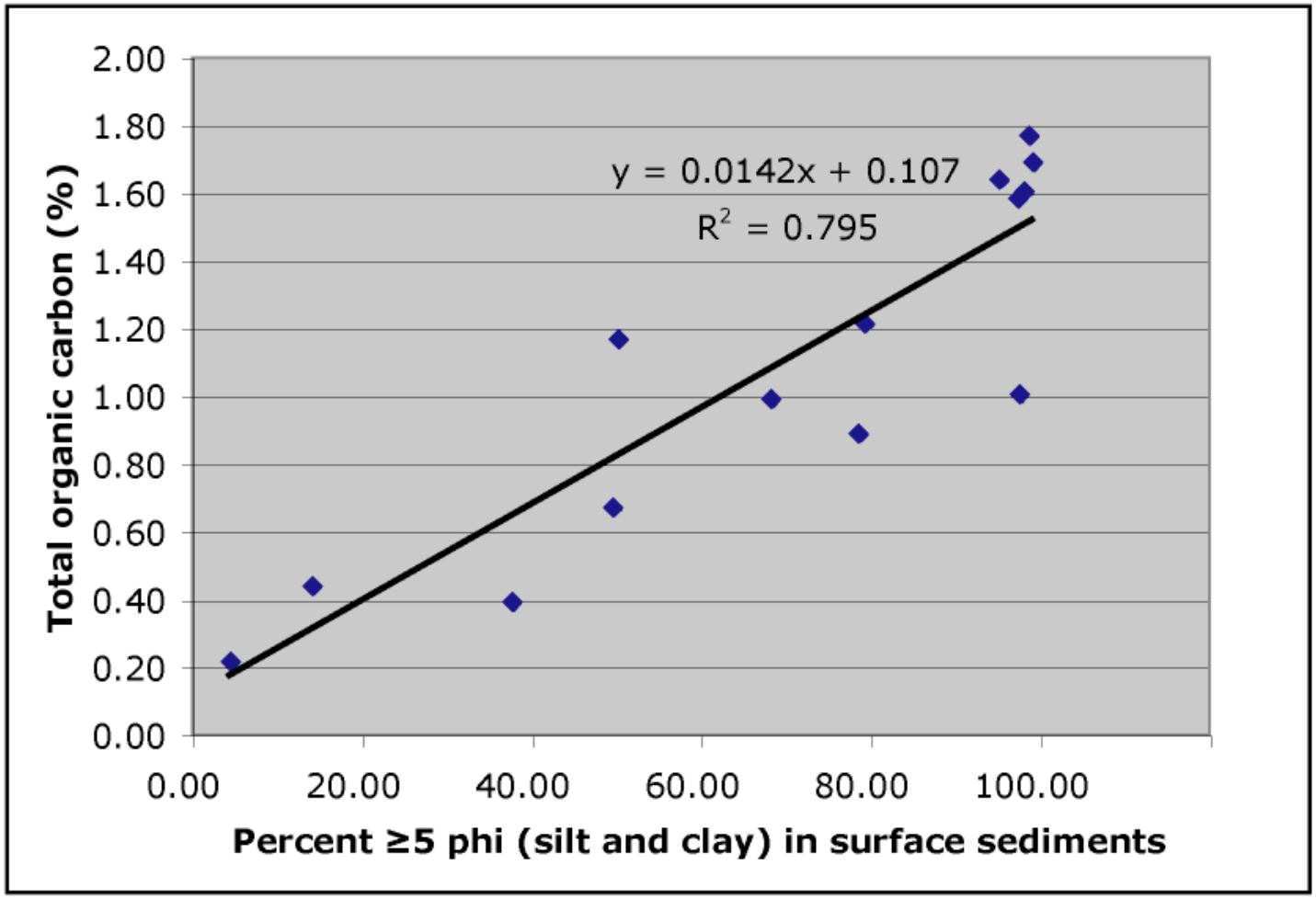
Barrow Canyon section

July-August 2002

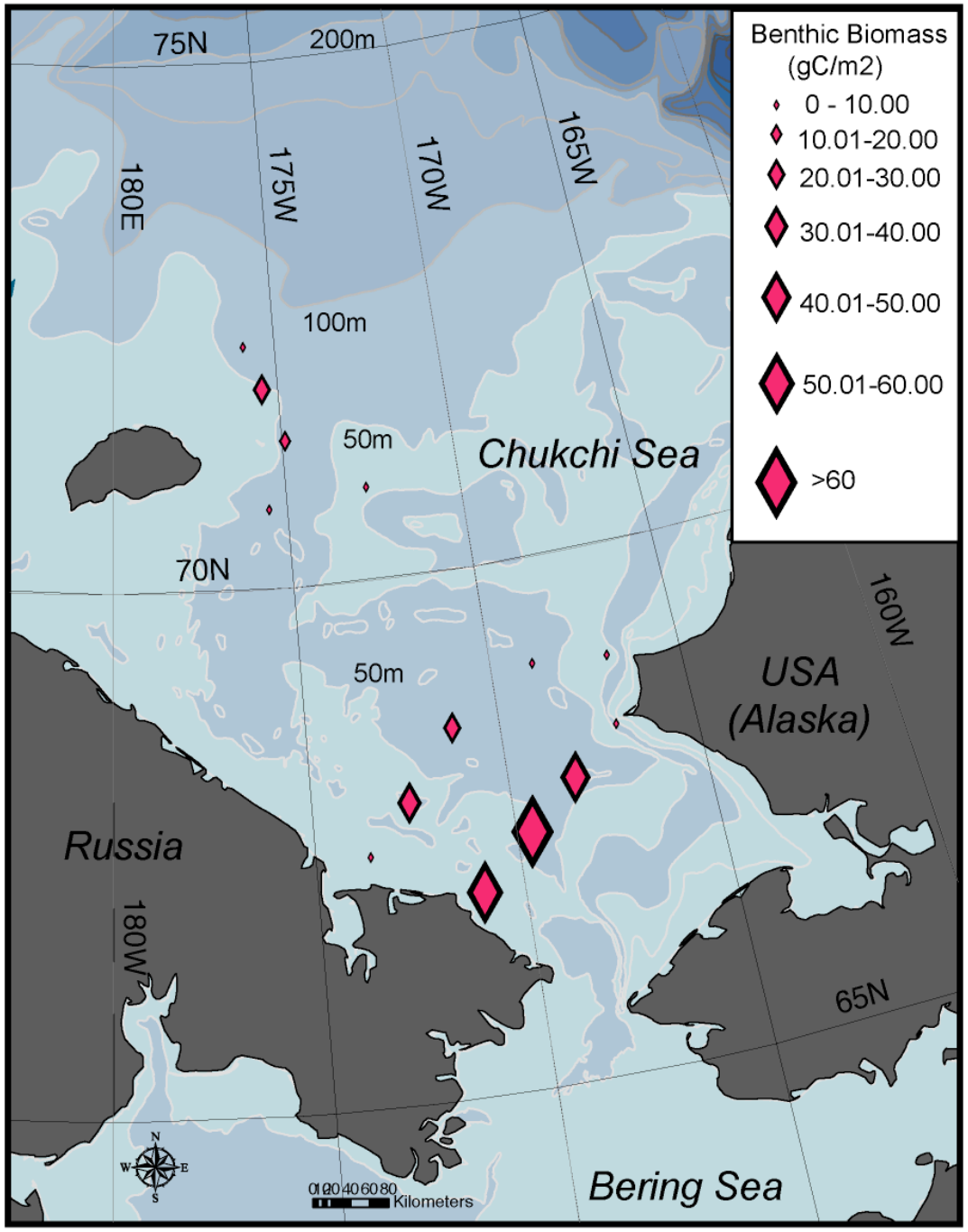


Sediment total organic carbon (%) for 3 cruises collected in July-August 2004

- RUSALCA on the RV Khromov
- Bering Strait Environmental Observatory/CCGS Sir Wilfrid Laurier (SWL)
- Shelf-Basin Interactions (SBI) USCGC Healy (HLY0403)
- highest TOC head of Hope Valley and downstream in Herald Valey
- also outer shelf/slope Chukchi Sea, slope of Beaufort Sea, and in upper Barrow Canyon



RUSALCA 2004

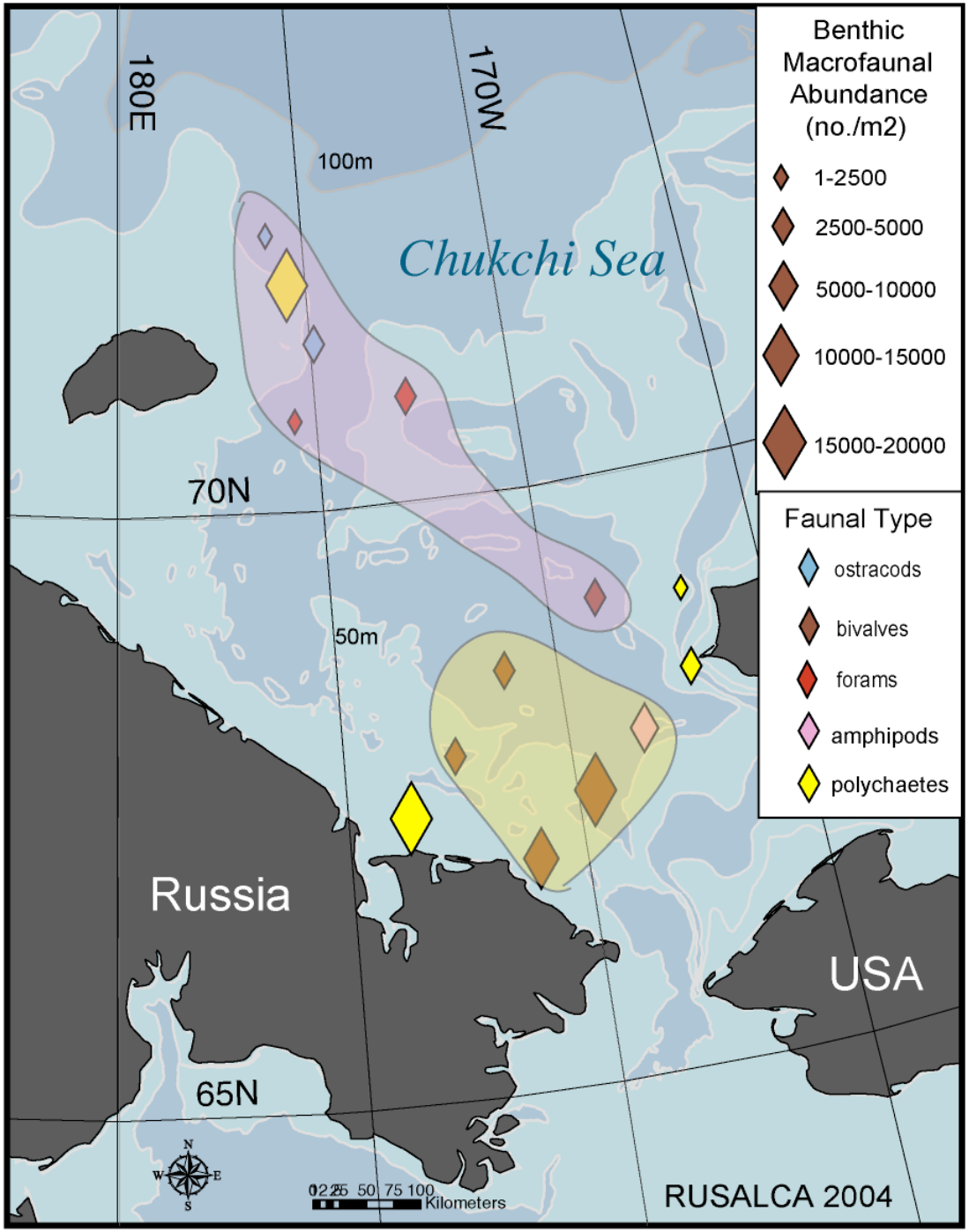


Benthic Biomass

(gC/m^2)

- "hot spot" region NW of Bering Strait in the SE Chukchi Sea at head of Hope Valley

- benthic biomass declines NW to Herald Valley



Benthic community structure for RUSALCA 2004 cruise, based on similarity indices of infaunal abundance

- two major cluster groups at 57% similarity level

yellow: "hot spot" in southern Chukchi Sea, high abundance level of bivalves and amphipods

purple: downstream Herald Valley group, dominated by polychaetes, bivalves, forams and ostracods

Individual sites: in fast current regions along coastlines, dominated by suspension-feeding polychaetes

Abstracts for Ocean Sciences Meeting, Honolulu - February 2006

Sedimentation Indicators of Organic Carbon Processing in the Chukchi Sea

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The Shelf-Basin Interactions (SBI) project has been a major new source of data and insights on the evolving response of Arctic ecosystems to environmental changes such as the increasing seasonal retreat of sea ice and warming ocean temperatures. However, the political division of the Chukchi Sea between Russia and the United States has limited SBI sampling to the U.S. sector, which limits direct observations of the transport of higher productivity waters in the Russian sector from Bering Strait north to the Chukchi shelf-break. The NOAA and Russian Academy of Sciences-sponsored Russian-American Long-term Census of the Arctic (RUSALCA) program has helped bridge this gap by providing opportunities for U.S. and Russian scientists to jointly sample in these higher productivity waters and sediments west of the International Dateline.

We present new data on indicators of recent sedimentation that provide insights on processing of organic carbon in both the western (Russian) and eastern (U.S.) Chukchi Sea. Surface sediment activities of the particle-reactive, atmospherically-derived radioisotope ^{7}Be (half-life 53d) indicate activities are highest in sediments immediately north of Bering Strait, and in down-slope portions of Herald and Barrow Canyons where Pacific-origin waters flow off the continental shelf. Chlorophyll concentrations in surface sediments show similar high concentrations on the shelf, with low concentrations in deep basin sediments. C/N ratios and δ^{13}C values of bulk organic carbon in sediments co-vary with lower C/N ratios and less depleted δ^{13}C values on the Russian shelf, consistent with less refractory and more readily usable, recently deposited organic materials. In down-slope and deep basin portions of the study area, these sediment indicators become more refractory, although relatively less depleted δ^{13}C values are observed over the entire outer continental shelf. Although this may be an indication of higher deposition of sea ice algae relative to water column production, we observed little difference in the carbon isotope composition of seston captured in floating sediment traps under ice-covered versus open-water deployments in 2004 in productive waters in Barrow Canyon. In general seston samples had significantly more depleted δ^{13}C values than underlying organic carbon in sediments indicating that in-sediment processing of organic materials has a significant influence on the carbon isotope ratios observed in organic matter in the sediments.

Additional Resources: http://arctic.bio.utk.edu

American Geophysical Union Abstract Form

Reference # 0000

1. Ocean Sciences 2006
2. AGU
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   (c)
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7. 0% published elsewhere
8. $70
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   American Express
   xxxx xxxx xxxx 71012
9. C
10. No special instructions
11. Regular author

Date received: October 17, 2005
Date formatted: October 17, 2005
Form version: 1.5

Benthic Community Structure, Carbon Cycling and Shelf-Basin Exchange on the Arctic Margins of the Chukchi and Beaufort Seas

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Pacific-influenced waters transiting northward over the shallow continental shelves of the northern Bering and Chukchi Seas and eastward into the Beaufort Sea are utilized and influenced by underlying benthic faunal communities. The 2002-2005 period has seen the largest decrease in the extent of Arctic sea-ice in the satellite record, and this seasonal sea ice retreat has been particularly dramatic in the shelf to basin region studied as part of several biologically-oriented programs, Western Arctic Shelf-Basin Interactions (SBI), the Bering Strait Environmental Observatory (BSEO), and the Russian-American Long-term Census of Marine Life (RUSALCA). These programs have permitted a broad scale view of biological dynamics that have direct influence on both ecosystem productivity on the shelves and downstream transport of nutrients and carbon to the Arctic basin. Benthic infaunal population analyses identify four communities: 1) the highly productive inner Chukchi shelf, including the "hot spot" region northwest of Bering Strait (dominated by bivalves and amphipods, station abundance=10,000-15,000 ind m^{-2} and biomass=20-100 g C m^{-2}), 2) the outer Chukchi shelf (dominated by bivalves, polychaetes and foraminifera; station abundance=1000-10,000 ind m^{-2} and biomass=10-40 g C m^{-2}, including the Barrow Canyon "hot spot" ($\sim$ 100 g C m^{-2}), 3) the slope region (dominated by foraminifera, polychaetes and bivalves; station abundance=1000-5000 ind m^{-2} and biomass (<10 g C m^{-2}), and 4) the deep basin (dominated by foraminifera; station abundance=1000-10,000 ind m^{-2} and biomass (<1 g C m^{-2}). The benthic biomass "hot spots" occur in the southern Chukchi Sea and in upper regions of Barrow Canyon that occur under Pacific-influenced high-productivity waters. In regions of high current flow low surface sediment total organic carbon (TOC) content (<0.5%) is found compared to high TOC accumulation regions (>1.5%) at the upper portions of Hope Valley in the southern Chukchi Sea, in areas downstream in Herald Valley, and in the upper regions of Barrow Canyon off Alaska. Patterns of sediment community oxygen consumption (SCOC) indicate similar spatial patterns within silt and clay sediments across the region, allowing for identification of sites of enhanced carbon supply to the benthos and nutrient efflux. The SCOC measurements ranged from 20-50 mM 0_2 m^{-2} d^{-1} in the "hot spot" areas in the southern Chukchi Sea and upper Barrow Canyon, to 1-10 mM 0_2 m^{-2} d^{-1} on the outer Chukchi and western Beaufort shelves, and declining to 0.1-5 mM 0_2 m^{-2} d^{-1} on the more northern slope and basin regions. Large-scale forcing by Pacific water inflow and seasonal ice dynamics directly influence these benthic processes, with potential consequences to ecosystem structure and off-slope carbon transport to the Arctic proper, including organic carbon transformation and fate in the transition from the marginal shelves to the Arctic basin.

Additional Resources: http://sbi.utk.edu

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